Appendix G. Non-native Species Threats in the Klamath Network

1.1. Introduction 1
1.2. Non-native, Invasive Plants 2
Invasive Plant Inventory Findings in the Klamath Network 3
1.3. Exotic Animal Threats 6
Mammals 6
Reptiles and Amphibians 6
Terrestrial Invertebrates 6
Aquatic Invertebrates 7
Fish 7
Birds 8
1.4. Exotic Pathogen Threats 8
Plant Pathogens 8
Animal Pathogens 11
1.5. Literature Cited 11

1.1. Introduction

The NPS Management Policies 2001 document defines exotic or non-native species as "those species that occupy or could occupy park lands directly or indirectly as the result of deliberate or accidental human activities." Biotic invasions are an enormous concern to the National Park Service and society as a whole because the consequences of their invasion potentially involve disrupting virtually all ecological processes (Mack et al. 2000). In national parks, there is great concern about the degradation or loss of ecological integrity. Ecological integrity refers to ecosystem wholeness, including the species, populations, and communities native to an area, and the occurrence of ecological processes at appropriate rates and scales (Angermeier and Karr 1994). All aspects of ecological integrity may be negatively affected when non-native species invade. Their presence, even in limited amounts, affects natural values and historic scenes. The NPS has long been concerned about non-native species and has developed many management guidance documents (summarized on the NPS invasive species monitoring website).

It is not possible to describe succinctly all the threats imposed by non-native species to the Klamath Network parks in this document. The purpose here is to instead review Network-wide and park-specific threats of greatest concern and then describe levels of invasion. These descriptions and some initial results of exotic vascular plant monitoring studies provide insight into what should be monitored, and where to expect problems with invasive non-native species.

Invasive non-native species have already considerably altered the biota of the Klamath Network. The biggest threat posed by invasive non-natives is disruption of entire ecosystems (Mack et al. 2000). Individual species may also be decimated by non-native pathogens, such as occurred with the American Chestnut in the eastern United States. Both of these kinds of concerns are present in the Klamath Network.

Epidemiologists use information about factors favoring the spread of a disease to understand its ecology and to reduce its impact (Shea et al. 2000). The same approach may be employed in strategies for dealing with the similar problem of non-native species invasions. Monitoring has much potential to improve understanding of the epidemiology of invasive species, and factors favoring the spread of exotics are important to consider for effective monitoring. Therefore, we provide information on these factors below.

1.2. Non-native, Invasive Plants

Non-native plant species consistently ranked among the highest priorities for biological inventory in the Klamath Network parks (Acker et al. 2002). Human manipulations of park environments, especially low elevation parks such as Redwood and Whiskeytown, have lead to high levels of invasion by non-native plant species. In fact, over 25% of the flora of these two parks is believed to be non-native species. At Redwood, cape ivy (*Delairea odorata*) and English ivy (*Hedera helix*) are invading old-growth redwood forests, while European beach grass (*Ammophila arenaria*) is displacing potential nesting habitat of the threatened snowy plover (*Charadrius alexandrinus ssp. nivosus*). Non-native annual and perennial grasses have invaded the Bald Hills habitat at Redwood and French and Scotch brooms (*Genista monspessulana* and *Cytisus scoparius*) could become widespread problems. Riparian areas at lower elevations (Redwood, Whiskeytown, and Oregon Caves) are keystone habitats particularly threatened by Himalaya berry (*Rubus discolor*) and other species. Chaparral woodland and low elevation forests at Whiskeytown are threatened by tree of heaven (*Ailanthus altissima*), French broom, and star thistle (*Centaurea solstitialis*). At Lava Beds, native bunch grass and sagebrush habitats are being encroached by cheat grass (*Bromus tectorum*), sweet clover (*Melilotus alba*), common mullein (*Verbascum thapsus*), bull thistle (*Cirsium vulgare*), and yellow star thistle. Among the worst generalist invaders are the thistles (bull, yellow star, Canada (*Cirsium arvense*), and Italian (*Carduus pycnocephala*)), which can wind disperse and colonize available habitat, even if it is relatively remote. All these species, as well as new ones that will invade, can become strongly dominant and alter ecosystem integrity and functioning by greatly diminishing the abundance of native species (Bossard et al. 2000).

In addition to cheat grass, there are a host of other non-native grasses that pose threats. These include Mediterranean annual grasses (e.g., *Bromus*, *Vulpia*) that are most abundant in the warm, dry low elevation environments of Whiskeytown and introduced perennials such as sweet vernal grass (*Anthoxanthum odoratum*) and tall oatgrass (*Arrhenatherum elatius*) that establish and thrive in wetter climates or microhabitats. Invasion of these species can be facilitated by positive feed back with fire (Mack and D'Antonio 1998). The rapid spread of cheat grass is a prime example of this phenomenon. It can foster frequent fire that eliminates shrublands. This is a major concern at Lava Beds. Cheat grass also occurs at Whiskeytown, but the shrub vegetation there is threatened mostly by Mediterranean annual grasses (e.g., *Bromus*, *Vulpia*), which invade after fire and can foster a reburn before shrubs have replenished seed banks or resprout reserves (Zedler et al. 1983). This can result in type conversion to grassland. The purposeful introduction of annual grass after chaparral fire, followed by reburning, has been used to convert extensive areas of chaparral to rangelands (i.e., grass foraging areas for cattle) in northern California (Sampson 1944). Ironically, treatments to prevent the spread of fire, such as the removal of woody vegetation to create fuelbreaks at Whiskeytown, may foster the spread of non-native grasses and other exotics (Keeley 2001). Monitoring will be essential to better inform managers and to allow them to carefully weigh fire and fuels and non-native species management objectives.

Disturbances in general favor the establishment of invasive non-native plants (Rejmanek 1989, Hobbs 1991). The combination of disturbance and non-native “propagule pressure” is a very strong predictor of landscape susceptibility to invasion (Keeley et al. 2003). Because non-native plants will most likely establish in areas that have both a ready seed source and undergo severe or repeated disturbance, human disturbed areas in parks such as campgrounds, corrals, hiking and pack trails, pastures, and road corridors, are particularly susceptible to establishment of non-native plant species. Among natural systems, those combining abundant moisture and nutrients with frequent disturbance, such as river corridors and riparian areas, appear to be especially vulnerable to invasion by non-native plants (Macdonald et al. 1988, DeFerrari and Naiman 1994, Stohlgren et al. 1998). Burn areas where resources are made abundant can also be quite prone to invasion, particularly in comparison to the same areas prior to fire (Keeley et al. 2003). Competition from established plants may also be reduced after fire (Tyler and D’Antonio 1995). In general, any disturbance that opens up intact, closed canopy vegetation, which may be highly resistant to invasion, creates areas susceptible to invasion. This has important implications for monitoring invasive non-native plant species.

Invasive Plant Inventory Findings in the Klamath Network

In 2003, an inventory project seeking to gather baseline information on the presence, distribution, and abundance of non-native plant species in five of the six Network parks (Redwood was not included) was conducted. From the information gathered, it is possible to describe exotic plant threats in greater detail than exotic animal or pathogen threats.

Three primary survey methods, singly or in combination, were conducted in each park: (1) site profile surveys of known disturbed areas, (2) targeted mapping of invasive species, and (3) establishment of quantitative belt plots for non-native vegetation. Additionally, a site information form, which summarized environmental conditions and vegetation characteristics, was completed for each survey site.

The results of these surveys clearly indicate that richness of non-native plants is greater at lower elevations. In 1-ha belt subplots, alien plant richness declined sharply from low elevations of Whiskeytown to the higher elevations at Lassen Volcanic (Figure 1). At low elevations, richness declined with belt distance from the road or trail, but this pattern was not evident at mid and high elevation sites. Most of the mid elevation sites were in Lava

Appendix G. Non-native Species Threats in the Klamath Network (continued).

Beds, where overstory vegetation cover was low. Most high elevation sites were in Lassen Volcanic, where richness was low overall. We also noted that the number of weed species was much lower in forest and chaparral vegetation than in more open steppe or woodland environments.

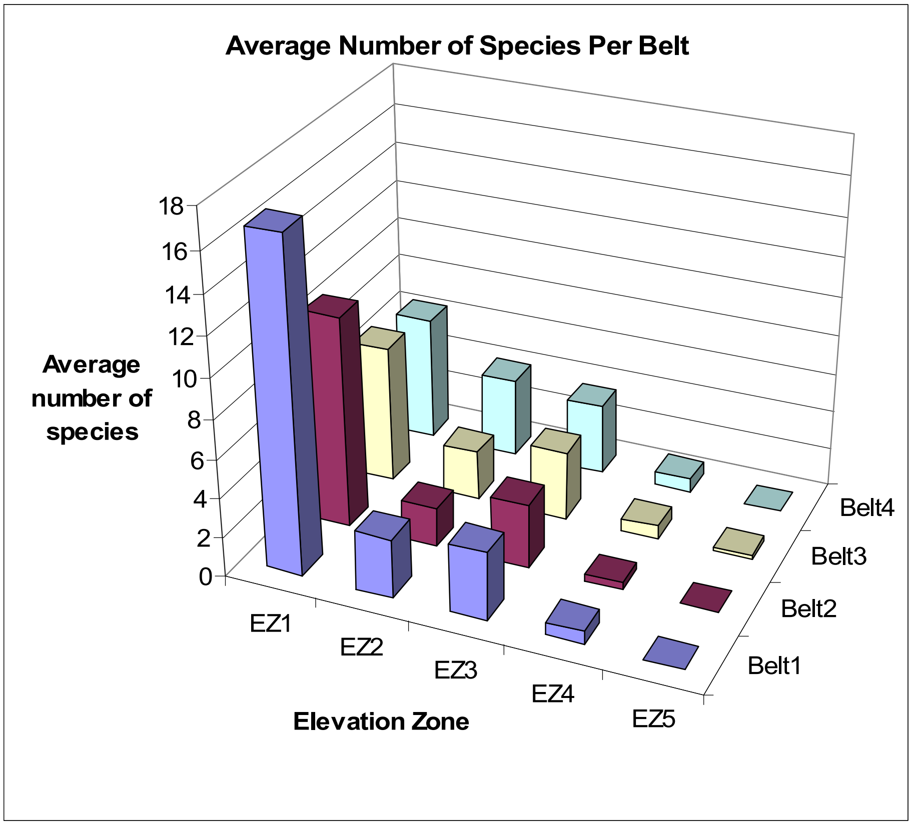

Figure 1. Average species richness in 1-ha quantitative belt plots grouped by elevation zone (EZ1= 0-500 m, EZ2= 500-1000 m, EZ3 = 1000-1500 m, EZ4 = 1500-2000 m, EZ 5= 2000-2500 m) and belt distance from a road or trail. (Belt 1 = 0-25, Belt 2 = 25-50 m, Belt 3 = 50-75 m, Belt 4 = 75-100 m).

Although we cannot eliminate the importance of unmeasured factors, these findings suggest the importance of the biophysical environment in controlling the distributions of many non-native species in the Klamath Network. Since all samples were collected near roads or trails that may provide vectors for invasion of non-native plants, it appears that climatic or other large scale factors, not dispersal, limit the species pool that can effectively invade the vegetation at a given location. Vegetation cover also appears to be a more effective control on non-native species richness than distance from a road or trail (i.e., belt number), suggesting that many of the non-native species in the Klamath region are more limited by light availability than by proximity to a source of plant propagules. Unique inventory findings for each park (except Redwood) are summarized below:

Appendix G. Non-native Species Threats in the Klamath Network (continued).

Crater Lake National Park: Throughout the park, a total of eight non-native plant species were found. Seven of the species were found on the section of Highway 62 from the southern boundary up to the Mazama Campground. Within the road surveys, the non-native plants were only found within three meters of the roadside. Within the three visitor use areas, the non-native plants only occurred in the most disturbed areas. These sites were usually against buildings, along walkways, or in the cracks of concrete parking areas. The four riparian areas surveyed contained two non-native plant species, common dandelion (*Taraxacum officinale*), and bull thistle. The dandelion patch was found only within the Lost Creek Campground along the stream. The bull thistle patch was found along Annie Creek within 100 m of the park boundary. The area on Annie Creek had light human disturbance, but looked as if it has periods of heavy flooding, which can cause soil disturbance. All of the non-native plants found within the park were directly linked to disturbance. Habitats from the roadsides into the native vegetation changed very little, however the non-native plants did not spread into the native vegetation

Lassen Volcanic National Park: Within the five quantitative belt plots installed in Lassen Volcanic, only one non-native plant species was found, common dandelion (*Taraxacum officinale*). It was found in two belts and was only located in wet, sunny areas or within three meters of a road. The quantitative plots contained almost no herbaceous plants—this was true in both highly shaded areas and in exposed, sunny areas.

The result of the purposive boundary surveys was similar to that of the quantitative belt plots. Dandelion was the only non-native plant found, and it was found only in wet riparian areas. These specific dandelions were possibly brought into the park by grazing cattle. There was evidence of livestock entering the park from the U.S. Forest Service land. In every area that cattle manure was found, dandelions existed. These areas consisted of small springs and streams, which are located miles from any trail or road.

The Lassen crew did not find any non-native plants during the boundary survey. Most of the survey fell within red fir forest or rocky outcrops covered with manzanita, neither of which commonly supports non-natives. However, the crew found several wet meadows along the western park boundary that would constitute sufficient habitat for bull thistle.

Lava Beds National Monument: Seven quantitative belt plots were installed in Lava Beds, and a total of 14 different non-native species were found. The most frequent species encountered was cheat grass (*Bromus tectorum*). Cheat grass was found in all four belts of every quantitative plot installed in the park. Overall, we found little difference in the total non-native plant diversity from disturbed roadsides into the native vegetation (i.e., between the four belts) within a plot. This may be due to the high amount of sunlight exposure throughout the park.

Oregon Caves National Monument: The forest in Oregon Caves National Monument is primarily old growth, and in very stable condition. The trail system in the park receives

Appendix G. Non-native Species Threats in the Klamath Network (continued).

moderate impact from visitors. The only non-native species found in the two quantitative belt plots was common dandelion (*Taraxacum officinale*).

1.3. Exotic Animal Threats

Mammals

Redwood and Whiskeytown have had feral pig (*Sus scrofa*) populations of in the past; they are no longer present in either park but could return. Feral pigs are a widespread, growing problem in California. They can cause drastic disturbance to an ecosystem while foraging or rooting. The process of rooting disturbs the soil and can uproot native plants. Feral pig rooting may be an exotic species positive feedback mechanism; one invasive species, feral pig, creates conditions that facilitate invasion by non-native plants, particularly thistles (D. Odion, personal observation).

Domestic cattle (*Bos taurus*) have been observed along the southern boundary of Lassen Volcanic. Domestic cattle have been suspected of depositing invasive plant seeds in the park. The Klamath Network non-native plant inventory 2003 found patches of dandelion near “cow pies.”

Three other non-native mammals: Virginia opossum (*Didelphis virginiana*), house mouse (*Mus musculus*), and black rat (*Rattus rattus*), have been confirmed in several parks; these species pose no major widespread ecological threat as long as they remain primarily in the vicinity of human habitation.

Reptiles and Amphibians

The bullfrog (*Rana catesbeiana*) occurs in all parks except Crater Lake and Lava Beds. This large amphibian is believed to be responsible for displacing smaller amphibians; the endangered California red-legged frog has been shown to be directly affected by the bullfrog (Lawler et al. 1999). Red-legged frogs have been extirpated in many areas, and many experts believe it is due to bullfrog’s competitive or predatory effects. The bullfrog has a reputation for preying on and eventually completely displacing native amphibians in general. Bullfrogs also prey on juvenile western pond turtles (*Clemmys marmorata*). The bullfrog is the dominant amphibian at Whiskeytown Reservoir. There it is believed to be abetted by non-native fish. Sunfish and bass in the reservoir prey upon dragonfly nymphs, which are predators of young bullfrog tadpoles. These tadpoles are not eaten by the non-native fish, however, because of their toxic skin. This pattern has been noted in the Willamette Valley, Oregon (Michael Adams, unpublished research) and may also apply in Whiskeytown.

Terrestrial Invertebrates

Isolated populations of the gypsy moth (*Lymantria dispar*) have been treated in Oregon. Currently, the species is not a direct concern in Oregon or California. However, the Oregon Invasive Species Council (2003) cites this species as “threatening to invade.” The moth can completely defoliate forests, stressing the trees and making them vulnerable to

Appendix G. Non-native Species Threats in the Klamath Network (continued).

mortality from a variety of causes. Other terrestrial invertebrates also mentioned as "threatening to invade" include the Japanese beetle (*Popillia japonica*) and imported fire ant (*Solenopsis invicta*).

The Africanized honey bee (*Apis mellifera scutellata*), a close relative to our friend the European honey bee (*Apis mellifera*), a benign non-native, is present in southern California. It is likely this species will eventually migrate north into the region, most likely in Whiskeytown. The Africanized honey bee is not an ecological threat; its aggressive behavior makes it a human threat.

Aquatic Invertebrates

Currently, no invasive aquatic invertebrates are known to occur in the Klamath Network parks. One species that is "threatening to invade," according to the Oregon Invasive Species Council, is the Zebra Mussel (*Dreissena polymorpha*). This species can spread via ballast water and invades coastal wetland communities. Redwood is the only park that is threatened by this species.

Boyd et al (2002) did a survey of non-indigenous species in Humboldt Bay, about 75 km south of Redwood, and identified many non-native aquatic invertebrates. One species they observed is the New Zealand Isopod (*Sphaeroma quoyanum*); this species has been identified by the Oregon Invasive Species Council as one of the state's "most dangerous invaders." Further information about the distribution of this species may prove valuable in controlling its dispersal.

Fish

The status of invasive fish within the Klamath parks is disconcerting from the perspective of ecological integrity. To address the status of invasive fish in the Network, we will address each park individually, except for Lava Beds and Oregon Caves, which have no invasive fish concerns.

Crater Lake originally contained no fish, but was stocked early in the 1900s. Fish planting ended in 1941, and today Rainbow trout (*Oncorhynchus mykiss*) and Kokanee salmon (*Oncorhynchus nerka*) exist in the lake. These species may have adversely affected salamanders (*Ambystoma macrodactylum*) and the Crater Lake newt (*Taricha granulose mazamae*) (Buktenica and Larson 1996). Brook trout (*Salvelinus fontinalis*) have been planted in Sun Creek, a Klamath River tributary. These introduced populations contributed to the population decline of the native bull trout (*Salvelinus confluentus*). Efforts have been implemented to restore the bull trout population.

Whiskeytown Reservoir contains several species of planted fish. Russ Weatherbee, Whiskeytown wildlife biologist, indicated five species of introduced fish as potential ecological threats: largemouth bass (*Micropterus salmoides*), spotted bass (*Micropterus punctulatus*), smallmouth bass (*Micropterus dolomieu*), green sunfish (*Lepomis cyanellus*), and brook trout. The direct effects of these species on the park ecosystem are unknown. Efforts are currently underway to determine the distance brook trout and smallmouth bass are able to penetrate into the tributaries of Whiskeytown Reservoir.

Redwood has non-native bullhead in Redwood Creek (H. Sakai, pers. comm.) and could possibly be infected with other marine and freshwater invaders. The park currently contains no known marine invaders. However, Boyd et al (2002) found a small population of mosquito fish (*Gambusia affinis*) in Humboldt Bay, about 75 km south. Mosquito fish can be found in estuaries and fresh water ecosystems. This species may have adverse effects on ecosystems after invasion (Fishbase.org 2004, Hole 1995).

At Lassen Volcanic, it is assumed, though not confirmed, that rainbow trout are native to Manzanita Lake. Non-sport species that are native to northern California, and recorded from Lassen, include the speckled dace (*Rhinichthys osculus*), Lahontan redside (*Richardsonius egregious*), tui chub (*Siphateles bicolor*), and mottled sculpin (*Cottus gulosus*)(Potts and Shultz 1953). Fish stocking was occurring before the park was established in 1916 and continued until 1992. Early stocking attempts were haphazard; many naturally barren lakes were stocked with a variety of fish. Baseline information on the current distribution and abundance of fish in the park does not exist. Because of the long history of fish stocking in the park, it is unclear today which lakes and streams were naturally barren, which contained native fish, and what species are native to each system.

Birds

Non-native bird species have expanded into the Network. Baseline park information on the distribution and abundance of these species, and their effect on native bird species, is limited. The Partners In Flight North American Landbird Conservation Plan lists exotic species as one of seven conservation issues facing the Pacific Avifaunal Biome (Rich et al. 2004). In general, as with plants, the worst problems are expected at lower elevations. The Brown-headed Cowbird (*Molothrus ater*) is a nest parasite whose aggressive and precocious young can interfere with the reproduction of a number of songbirds. During the 2002-2003 avian Klamath Network inventories, cowbirds were detected at Crater Lake, Lava Beds, and Whiskeytown. European Starling (*Sturnus vulgaris*) competes with native species for limited cavity nest sites. Starlings were detected at Lava Beds and Whiskeytown during the inventories. Turkeys may be in several of the parks, but are not yet common. The non-native Barred Owl (*Strix varia*), believed to compete with the northern spotted owl (*Strix occidentalis caurina*), is of concern across the region.

1.4. Exotic Pathogen Threats

Plant Pathogens

There are two ongoing exotic pathogen epidemics in the parks which are severely impacting native species. Port-Orford Cedar root rot, caused by the water mold *Phytophthora lateralis*, and white pine blister rust, caused by the fungus *Cronartium ribicola*. In both cases, the impacted species provide keystone ecosystem functions.

Appendix G. Non-native Species Threats in the Klamath Network (continued).

Unfortunately, there is another emerging epidemic of concern nearby, Sudden Oak Death, which also affects species that provide keystone functions.

Port-Orford Cedar Root Rot: *P. lateralis* is lethal to Port-Orford Cedar, which it can readily enter through the tree's roots. Port-Orford Cedar (*Chamaecyparis lawsoniana*) is a distinctive conifer that dominates riparian and spring-fed ecosystems and some surrounding moist forests in northwestern California and southwestern Oregon (reviews by Hayes 1965 and Zobel et al. 1985), including Redwood and Oregon Caves. Primeval old growth stands of Port-Orford Cedar at Oregon Caves are at high risk for infection.

Because of the severity of the disease, Port-Orford Cedar is considered to have suffered the most from human impacts of any major forest trees in western North America (Noss et al. 1999). Port-Orford Cedar often grows in the active channel of creeks, for example at Oregon Caves. The root systems of the mature trees, as well as the remarkably rot-resistant wood, play important roles in structuring creek channels and riparian areas (Hansen et al. 2000). The decline of Port-Orford Cedar, triggered by the spread of this disease organism, will irreversibly eliminate native stands and their mature and old-growth structure that is vital to the healthy functioning of forest-riparian ecosystems. The disease may limit the functional role of this species to the few remaining pockets of uninfected individuals largely in roadless areas within its range. *P. lateralis* also infects western yew (*Taxus brevifolia*).

P. lateralis has a mobile aquatic life history stage (Hansen et al. 2000). The aquatic zoospores disperse in runoff. There are also resting spores, which can be dispersed in soil picked up by vehicles and passers-by. These factors allow inferences about the epidemiology of the disease (summarized by Jules et al. 2003) and have implications for designing effective monitoring of disease spread.

White Pine Blister Rust: This disease, caused by a true fungus, *Cronartium ribicola*, is likely to have similarly devastating consequences as *P. lateralis*, but in very different environments. The white pine species it threatens in the Klamath region includes western white pine (*Pinus monticola*), sugar pine (*P. lambertiana*), and whitebark pine (*P. albicaulis*), all of which are highly susceptible. As described by Murray (2004), there is much concern about the loss of whitebark pine. It is the only North American representative of the pine subsection Cembrae, or stone pines, an exclusive group distinguished by large, wingless seeds within cones that stay closed when ripe. In the Cascade Range, whitebark pine often forms pure stands at timberline, at higher elevations than other trees can tolerate. It extends above timberline in dwarfed (Krummholtz) form. Thus, the pine forms a forested ecosystem where otherwise only meadow or sparsely vegetated slopes would exist at Crater Lake and Lassen Volcanic.

Blister rust was formally detected on the whitebark pines at Crater Lake in 2000. Based on conservative estimates, infection ranges from zero on the east side to 20-26% on the west side of Crater Lake's Caldera. There are many long-since-dead whitebark pines on the west side of the Caldera, indicating that the disease has been present for some time prior to formal detection. At current rates, about half of the westside pines will be gone by 2050. In Lassen, a fair number of sugar and western white pines, even in dry central plateau habitats, have symptoms consistent with white pine blister rust infection. In addition, symptoms and indicators of blister rust on whitebark pine have been observed (J. Arnold, Lassen Volcanic NP, pers. comm.) but the disease has not been confirmed in this species. Host plants for the disease are uncommon or absent in the other parks.

Blister rust is a fungus. It has an alternate set of host plant, currants and gooseberries (*Ribes* spp.). It has been discovered that the fungus can move only a small distance from these hosts to pines, but that after infecting a pine, it can move a long distance to other host plants. So the method of control is to eliminate the host plants within the necessary radius. Programs to develop resistant pine varieties and plant them are underway in earnest. It is unclear at this point whether the five-needled pines of the west will be decimated, including those in the national parks.

Sudden Oak Death: This disease is an emerging epidemic that will soon be a serious concern in the Klamath Network. It is a new forest disease that has spread rapidly since 1995 and reached epidemic proportions in much of the central coastal region of California. It has also been found in Oregon tanoak forests (Goheen et al. 2002), as well as nurseries in California, Oregon, and northward to British Columbia. A newly-discovered pathogen, *Phytophthora ramorum*, another water mold, causes the disease, which takes two distinct forms (Rizzo and Garbelotto 2003): main stem infections on some oaks and foliar infections on tan oaks and other plants. In certain oaks (*Quercus* spp.) and especially tanoak (*Lithocarpus densiflorus*), lethal branch and main stem infections occur. In tanoak and other plants, *P. ramorum* also causes foliar infections. Most of the woody plant species and at least one herb within the current range of the epidemic have been found to be susceptible, including such important trees as redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menzesii*) (Rizzo and Garbelotto 2003). It is believed that foliar infections can kill Pacific madrone (*Arbutus menziesii*) and possibly Douglas-fir (Goheen et al. 2002). It has not been confirmed that *P. ramorum* is an exotic, but it is strongly suspected to be. Regardless of its status, there are some ominous considerations and disturbing coincidences: 1) *Phytophthoras* are the most devastating pathogens of dicotyledenous plants (Kamoun 2000); 2) The origin of *P. ramorum* is thought to coincide with that of *P. lateralis* and be in Asia; 3) *P. ramorum* and *P. lateralis* are more closely related genetically to each other than any other taxa in the genus *Phytophthora*; 4) The closest North American relative of the species most susceptible to *P. ramorum*, tanoak, is the north American Chestnut, which has been driven to extinction in the wild by an Asian pathogen; and 5) Oaks and tanoak in particular produce an enormous food resource, acorns, which myriad wildlife depend upon. Thus, there is widespread concern about the disease’s cascading ecosystem effects.

A recent publication (Meentemayer et al. 2004) concluded that the northern Sierra, southern Cascades, and especially the western Klamath region are at high risk for Sudden Oak Death. One factor favoring the spread of Sudden Oak death appears to be past fire occurrence. Moritz and Odion (2005) have documented a striking, highly significant

Appendix G. Non-native Species Threats in the Klamath Network (continued).

absence of the disease in areas that have burned in recent decades. The relationship is not caused by biased monitoring for the disease away from burns, but instead appears to be related to nutrient and chemical changes that occur in the absence of fire that weaken hosts and favor the pathogen. These changes are reversed by fire.

As illustrated by the relatively recent emergence of these pathogens, the phenomenon of introducing diseases for which hosts have no evolved resistance is an increasing problem. For example, additional *Phytophthora* diseases in Oregon and California have recently been described (Hansen et al. 2003). There are reasons for concern beyond the possibility that these may be non-native. Hybridization or genetic exchange among *Phytopthoras*, or possibly among other pathogens in other genera, can allow for greater genetic variability, which could lead to more virulent strains of *P. lateralis* and *ramorum*. This can undermine the durability of host resistance developed in breeding programs. Thus, the development of Port-Orford Cedar cultivars that are resistant to *P. lateralis* does not protect this distinctive tree from the same fate as American Chestnut. Its existence as a wild species is still threatened.

Animal Pathogens

Chytrid fungal diseases first emerged in 1998. They occur worldwide, so native vs. non-native status is unclear. They are a serious threat to amphibians about which further information is needed. We were not able to identify existing exotic animal pathogen problems presently occurring. In the past, domestic sheep diseases decimated reintroduced big horn sheep at Lava Beds (D. Larson, Lava Beds NM, pers. comm.).

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